Design of a Computer-Based System for ~~Editing Videotapes~~ Videotape Editing

~~On the Details of Computerized Videotape Editing~~ ~~Controls and Its Implementation~~

Theodor H. Nelson

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67-2777

The Nelson Organization
Box 1546
Poughkeepsie, New York 12603

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This note will discuss ~~in detail certain aspects of a~~ a computer-based videotape editing console, ~~under computer control, with a computer nerve center,~~ designed to speed up ~~videotape~~ editing and enrich the editor's options. The general design was discussed in an earlier note, "A Sophisticated System for Videotape (and Motion Picture) Editing." In part this is an expansion of ideas presented before the Society of Motion Picture and Television Engineers in 1965, to be published in a larger version in the J.SMPTE later this year.

However, other contents are proprietary, and are here presented in confidence. Certain ideas in this paper may be patentable, and their enclosure in this proposal does not constitute their publication or relinquishment.

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[new page] INTRODUCTION

It is now possible to put a computer at the nerve center of videotape editing, and therefore film editing (by means of videotape) as well. The details of switching and controlling tapes may be concentrated and consolidated in the computer, simplifying the editor's job. Individual shots will be automatically ~~assembled into~~ shown in consecutive sequences ~~under the editor's direction. In addition, new services may be designed and programmed into~~ that the editor wishes to examine, or assembled into final sequence on a single tape. The system is designed to simplify ~~bookkeeping,~~ record keeping, render comparisons more convenient, and clarify decisions. And it is open-ended, ~~so well~~, so that new services may be designed and programmed in.

¶ The user's controlling actions in this system will be ~~It should be emphasized that the user actions will be ex-~~ extremely quick and easy, ~~Otherwise the system would be too much trouble.~~

~~contrary to the popular impression image is unfortunately the opposite.~~ that computers are extremely "difficult" and always "numerical." ~~Neither of these is true. A~~

A ~~#~~ computer-based system should always simplify and clarify human activity, making work easier and quicker. ~~The popular~~

Use of the ~~The~~ system to be described here, ~~is intended to simplify and clarify. The~~ can be learned in an hour, takes over bothersome details to the extent that the user need never see a number unless he wants to use them.

¶ This paper describes a high-capability system, ~~without shortcuts.~~ Lesser systems are of course possible, and would be easier to implement.

But the ~~simplicity and~~ power and simplicity of operation described here require the entire plan. There is no point in expending effort on ~~the less important system.~~ a system that is less complete.

¶ Nothing described in this proposal imposes any ~~strain~~ on computer technology. The difficulty ~~is~~ in ~~has been the~~ design of useful services, rather than limitations of machine capability.

No ¶ ~~S~~ This paper ~~is intended merely to state in detailed outline~~ describes a set of technimques and services, currently possible, that will make such a system worth while. ~~currently possible and worth beginning, and persuade the reader that the system is currently possible.~~

[new page] SYSTEM BEHAVIOR AND SERVICES

The purpose of this system is to speed up, simplify, clarify and enhance all the operations of videotape editing, without introducing any restrictions or distractions. All the detailed manipulations are to be performed by the computer according to ~~an~~ evolving lists, inside it, of the shots~~xx~~ and sequences the editor is interested in.

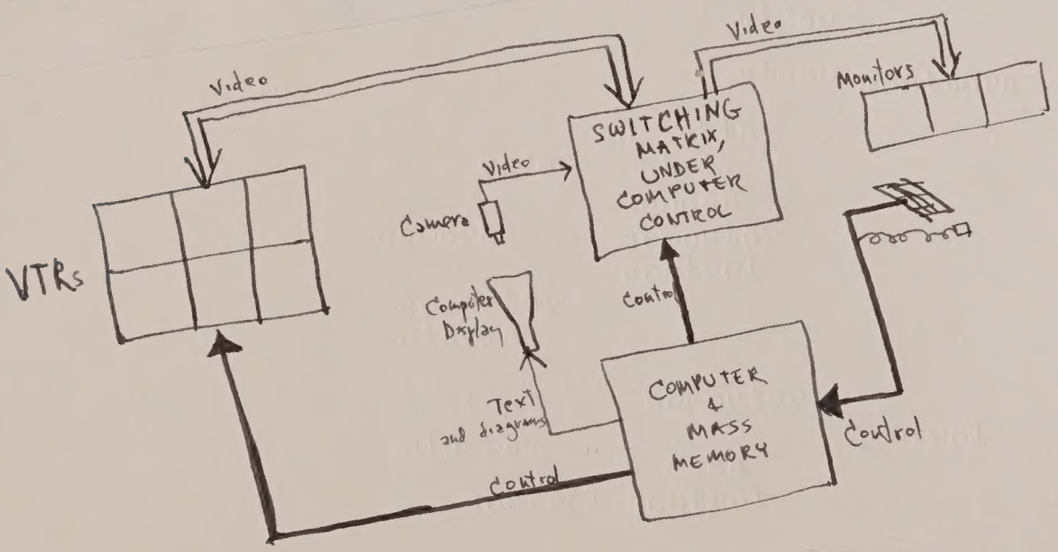
~~The~~ The editor does not handle tape. ~~unless he has mounted it on the recorders himself.~~ He sits among monitors and special controls.

mounted

The works of the system are elsewhere. videotape recorders A number of (VTRs) are connected to the system and have tapes mounted on them. These include both the recordings of interest and blank tapes that will be used for temporary storage.

Also out of sight is a small, high-speed digital computer, having a medium-sized disk memory. Also attached to the computer is a cathode-ray display on which sectors of text stored in memory can be quickly shown and replaced.

All video connections, from and to VTRs, from the computer display camera, and to the monitors, go through a switching matrix which is controlled by the computer. The editor's controls go into the computer.



¶ The operations of the system are actually carried out by a complex computer program which takes notes of the editor's actions at the controls, ~~computer requests with~~ consults lists of information ~~on its disk file, memory, shows parts of these lists to the TV camera, calculates the best way~~ ~~to find and copy shots stored on tape,~~ and moves VTRs and sets switches accordingly. It also presents the editor's written notes on the monitors in a way that lets him pick and choose easily.

¶ These screen notations ~~are sheets~~, not only replace the use of clipboards for jotted remarks, ~~about~~ but add the capacity for automatic rearrangements, ~~but the~~ furnishing convenient handles the man and the computer can mutually refer to. ~~understand and rearrange. These~~

of VTRs, and ~~record keeping refers~~ keeping records of where is carried out automatically by the computer and its program.

The general sequence of operations is as follows. The editor views the original videotape and types ~~names~~ shot descriptions and comments into a keyboard (or dictates them to a secretary, who types them in). By punching buttons at the start and stop of the shots that interest him, the editor (or an assistant) informs the computer where the shots are that are to have these names and comments attached. ~~(He may also assign the shots to categories, pointing at category lists that list categories in lists on the screen.)~~

¶ The editor may now call to the screen ~~these names, and~~ his shot ~~descr~~ names or descriptions, and point at the ones he wants combined into sequences. As he points at these names with a special device, they appear in a new list on the screen. He may move these names around till the sequence seems right.

¶ He may at any point stop and view the sequences in the order he is considering. The computer examines the lists he has prepared,

and the corresponding videotapes, ~~are~~ automatically copied and ~~recombined~~ ~~according to the lists~~ he has prepared, recombined, are soon ready for viewing.

¶ ~~He~~ The editor may continually revise the lists (and make variations of them), and have the computer show him the resulting sequences quickly. And he may work over the details of splices and cutting-points carefully until he is done.

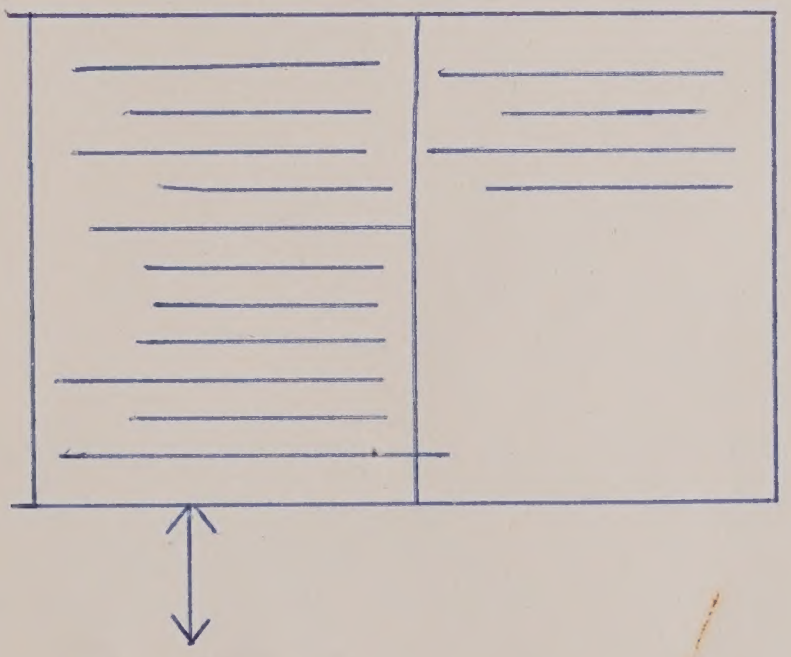
That is the basic system: view, ~~xixix~~ select, trim and ~~rerunnix~~ reconsider. Repeat in any order until done.

¶ If ~~necessary~~ the editor may ask for a second-generation ~~tape~~ he wants, final copy. The computer will then arrange to copy every shot from the original tape into a final composite.

~~Controlling Shot Rearrangement by Title or Description~~

[new page] Mechanics of ~~Shot Rearrangement~~ Shot Rearrangement

¶ For the creation of sequences to be assembled — "assembly lists" — the screen is divided ~~One possible arrangement would divide the screen~~ into two vertical sections. The left section ~~would~~ "looks into" a ~~x~~ list of the shot~~s~~, descriptors. ~~x~~ Although only part of the list ~~could~~ is can be seen at any given moment, the user ~~would have a~~ has a left-hand throttle permitting him to "scroll" up or down the list. The list ~~would then~~ moves backward or forward on the screen ~~like a~~ as if from a drum titler, with new items appearing at the bottom edge as the old ones disappear~~ed~~ at the top-- or vice versa.



The other half of the screen ~~would~~ holds the ~~evolving~~ developing assembly list, which the editor can move up and down with a right-hand throttle if it more than fills the screen. The editor ~~would point~~ points at the item he wants in the ~~xxxx~~ shot description list, it ~~would~~ blinks acknowledgment (so he ~~could~~ can make sure he ~~x~~ ~~had~~ has pointed correctly), and then he ~~would~~ points at the place he ~~wanted~~ wants that shot inserted on the assembly list. In a flash that item ~~would be added to~~ is added to the assembly list; and, if it ~~had~~ has been placed between other items, those other items ~~would have~~ moved apart to make room.

¶ "Pointing" to specific ~~sepect~~ words on the screen ~~would probably not be with the usual light pen, which ordinarily does not work with a TV screen, but rather~~ is done with an Engelbart Mouse, ~~which is~~ a small box on wheels which you roll around the desktop, and whose position is keyed to corresponding positions on the screen. This instrument is one of the simplest and cheapest pointing devices, and is easy to install.

¶ The internal mechanism of shot rearrangement is a matter of computer programming. For each shot that ~~Essentially, when a shot description~~ is chosen, the computer looks up the number of the shot having that description, finds its location in the shot address table, spaces appropriate VTRs forward and back, and transfers the shot accordingly. ~~The details are black magic (programming).~~ The computer program calculates the quickest sequence of operations by which to make this copy, and then carries out the operations by itself.

Carrier

Framing

[new page] Shot descriptions and Titles

¶ Let us consider some flexible aspects of this ~~title-manipulation system of~~ manipulating shots by their descriptions and titles. ~~system.~~

¶ The choice of shot titles can be quite free. ~~and very versatile services can be designed around them.~~ Words of any length, phrases and whole paragraphs may be used. If editors want to work (of course, with numbered shots, they may. Or ~~work~~ they may mix words and numbers, as in "Kiss 3" or even ~~"A IIQ."~~ "A 7Q." ~~many issues of taste are involved. Some editors may want to work with numbers. This is permitted too.)~~

3

The titles of shots can have details that are useful or that distinguish between them:

SHE STEPS TOWARD HIM (HAIR STREAMING)

They can contain information on photography:

THEY FACE EACH OTHER (PAN SHOT)

THEY FACE EACH OTHER (TWO SHOT CU)

The editor may not ~~However, you may not necessarily~~ want all that information on the screen when compiling assembly lists. ~~The editor may want~~ It will be possible to manipulate short titles on the screen but have more written details available. Suppose a shot had the following full title:

THEY WALK. HE LOOKS HAPPY; SHE LAGS A LITTLE, APPREHENSIVELY

When desired, the editor could have this reduced; for example, to:

THEY WALK. *

or

THEY WALK. * SHE LAGS *
~~XXXXXXXXXX~~

(The asterisk reminds the editor that he has more details in the title if he wants to see them.) At different stages of the editing process, different parts ~~phrases~~ of the shot descriptions can be included in the screen caption.

An alternative shortening method is simply to cut off the shot description at the end of the first line. ~~Obviously~~ the editor may have his choice of how to shorten the shot descriptions.

One shot can be divided up different ways, and the resulting clips can be given different names. ~~(But the editor will always~~

Shot descriptions can also overlap in various ways. For example, all the different shots of the same event may have a common description (easily copied with a 'ditto' facility), and with qualifying phrases or codes alongside. (If an actual script is included in the system, as described below, the tie-in of that script will also involve considerable overlap among shots.)

Not only individual shots, but assemblies of shots, can be given names, and be transferred to tapes automatically by the user's placing these names on an assembly list. Such conglomerate names might for convenience end in "scene," "sequence" and "number," e.g., "Love Scene," "Chase Sequence," "Chorus Number."

It will therefore be possible to create the whole work from finished scenes by simply listing the scene names and commanding ~~giving other instructions that command~~ a final copy to be made.

36 For instance, a commercial can be ordered into existence simply by naming its parts (which have already been finished separately):

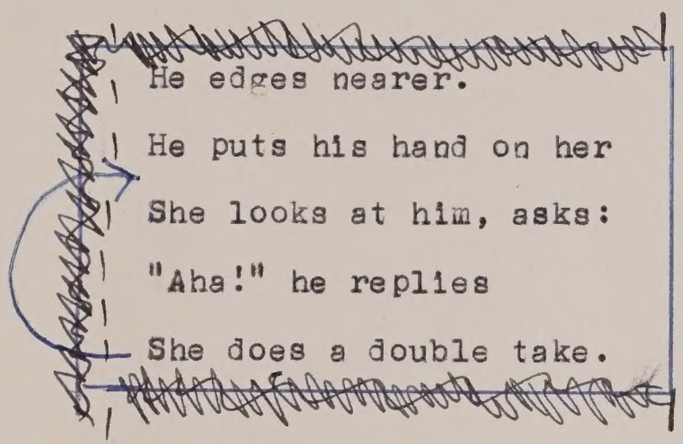
BEACH TEASER
BOTTLE POURING
SPLASH MONTAGE
DANCING
BOTTLE/GIRL MONTAGE
SUNSET, WITH PRODUCT

Just because a shot or sequence has been described and listed does not mean the editor has to use it. The editor may list for assembly all the shots in a given category, or all the out-takes in a given scene. He may also create different assembly lists for the same scene, giving them slightly different titles, in order to examine possible variations.

No ¶ All these assembly lists are kept on file so that they for immediate viewing when wanted.

¶ Assembly lists may be rearranged.

~~He can then examine the assembly list~~. If something is in the wrong place, ~~he~~ the editor can move it around with the pointing device, until it is ready.



Editor points at bottom line.
It blinks.
Editor points between second and third lines.
Text can either jump, or move through other text.

¶ ~~Naturally, a shot assembles cannot be kept available for viewing indefinitely~~ As new assembles are made, they have to obliterate old ones on the temporary tapes, ~~however~~ the editor may decide which scenes are to be kept available immediately.

¶ All lists, including assembly lists, would remain on the computer system even if the corresponding videotapes were removed from the VTR.

~~75~~ ~~35A~~ 15

[drop]

The use of text on the screen is not the only possible method for keeping track of ~~shot~~ information about specific shots, although it is perhaps the most versatile.

Another possible scheme would put selected frames from specific shots into some device on which they could later be reviewed quickly-- either a VTR or a video disk. The editor could see them immediately in stop-frame mode, to refresh his memory without seeing whole shots. (They could be overlaid with symbols and arrows to indicate motions, and with comments, etc.)

It would also be possible for the editor to dictate his comments directly into the system. They would be stored as audio on some addressable tape device, possibly a VTR, and be heard along with, or before, the shots during which the dictation occurred.

~~Unfortunately,~~ ¶ Of course, this would not lend itself to painless re-sequencing the way that the written text in the computer can ~~does.~~ However, it might be a good method for handling a lot of minor comments worth reviewing.

Line drawings can be included, and allow the editor to store, and superimpose, rough animations of the compositions he wants to try, in sequence.

[new page] ~~CATEGORIZING~~ Categorizing

When he types in the shot descriptions, the editor may also choose to put the shots in categories. The categories are to be of his own ~~xx~~ selection, of course. Shots can be indexed on many categories, ~~x~~ including quality. For instance:

Subject

Hero
Heroine
Villain
etc.

Quality of composition

Magnificent
Good
Fair
Acceptable
Lousy

Movement type

Still
Camera movement
Subject movement
Background movement

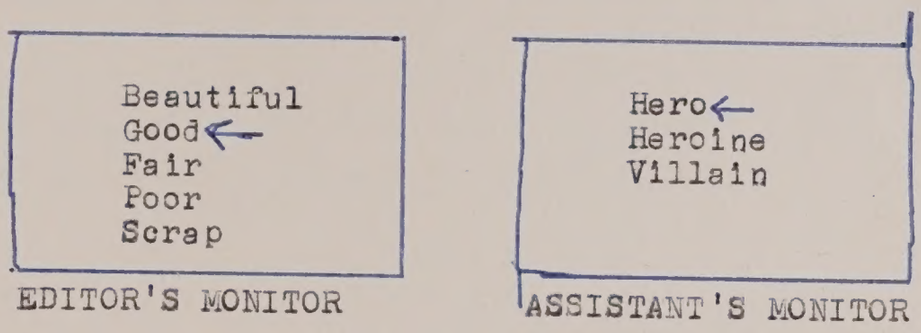
Movement speed

Slow
Medium
Fast

Assigning shots to ~~these~~ such categories requires no tricky abbreviations or coding forms. After each shot the list can roll by on the screen, and the editor can simply point at the attributes it has, or add to the list attributes he has previously left out. For simpler attributes, such as who is in the shot, these matters could be decided by an ~~xxxxxxxxx assistant.~~ assistant at another monitor.

#5 17

[not a new heading] → SIMULTANEOUS CATEGORY DISPLAYS



To save time in some applications, the category lists could be superimposed on the passing picture.

The editor may ask, then, to see all shots having any of his categorized properties, or any combination of these properties.

He may also ask the total running time of shots in a category, or combination of categories.

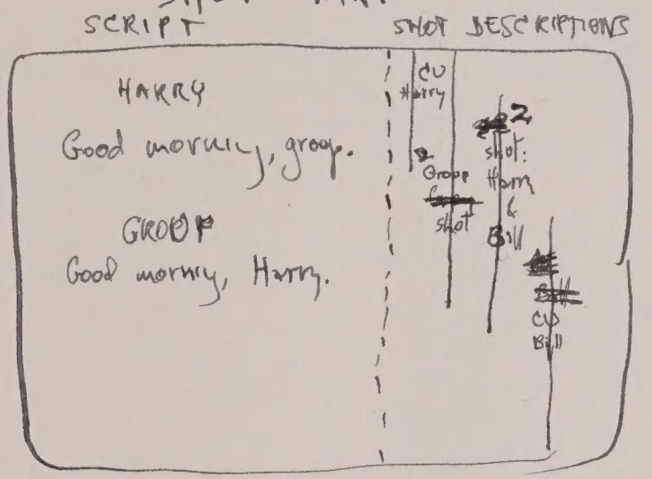
Or he may ask ~~for list~~ to see his own shot descriptions ~~of everything~~ of all shots in a category (or a combination of categories), with or without their running times.

[new page] Script Services

¶ The correspondence of specific shots to the script, if any, would have to be ~~of course, the script correspondence~~ logged into the system, ~~in a manner similar to the handling of categories; (unless it could be done in advance according to some sort of production manager's record)~~. although, as with categories, this part of the work could be handled by clerical personnel.

¶ Once the shots have been logged to the script, the editor can request a "shot ~~map~~ map," as follows:

"SHOT MAP"



(Note that if the shots logged in are ~~greater than the~~ more than will fit on the right half of the screen, they can be made narrower, or can be controlled by a throttle, which scrolls them sideways.)

narrower

¶ An assembly list can be picked from the Shot Map as well.

¶ The editor may also request shots ~~that have a certain connection to the script list, or particular connection codes.~~ that are connected to specific parts of the script; for instance, "put together all the shots from here to here." But

~~When there is a fixed script in the system, it can be used~~
¶ The script can also be used
to provide a quick written summary of the cutting. The editor
may ~~would~~ ask the computer to display the shot descriptions ~~in a~~
of a specific assembly list next to the script, in corresponding order:
~~specific assembly next to a script:~~ ~~the parts of the script they correspond to:~~

SCRIPT	SHOT DESCRIPTIONS IN PARTICULAR ASSEMBLY
(We see the latch slowly raised. The door opens. A nose appears.)	CU latch Perspective shot of nose. Pan to the waiting gunman. Two shot of RANDY & UNCLE BILL.
RANDY Gee, a nose!	
UNCLE BILL Don't be too sure, son.	

[new page] Trim Control
~~TRIM~~
~~LAP CONTROL~~

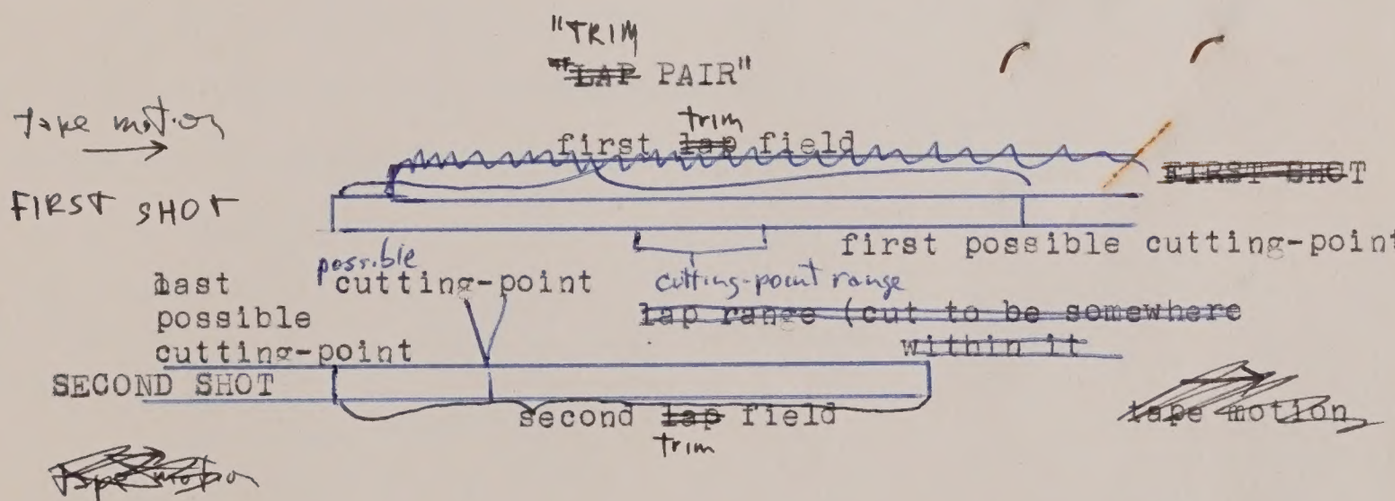
¶ A crucial problem in the editing of both film and videotape is deciding ~~One of the problems in film editing, and pro presumably~~ where to make a cut between consecutive shots. Typically there are two decisions to make, unless the shots are synched to a common event or sound track, in which case there is only one.

synched sound

Let us call this the problem of ~~"lap~~ "trim control." The system under discussion can offer services to ease the editor's task when decision is difficult.

The following diagram suggests terms which ~~wi~~ will help discuss the issue.

42



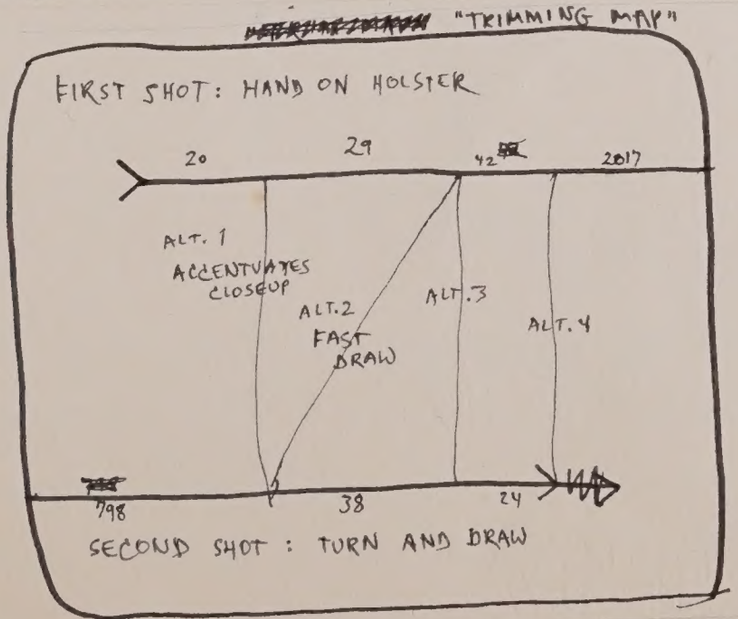
In the system under discussion, the editor specifies to the system through pushbuttons that two particular shots are consecutive. He then views the shots, and specifies the cutting-points he would like to try, or the ranges within which he thinks

he would like to cut. He may, in addition, type in or dictate remarks on the different cuts.

After a pause, the system is ready to show him the several ~~trim lap~~ alternatives in quick succession. Before each ~~trim lap~~ pair, his comments on that alternative are displayed on the screen or played through a speaker. The closing part of the first shot is shown, and then the first cut he has requested is seen. The system is immediately ready to show the next ~~trim lap~~ pair, then the next, and so on. (It should be pointed out that the editor cannot usually ask to see "all combinations" of the cutting points in the leading and trailing shots, since the number of shots may grow astronomically. If the editor is considering five cutting-points on the leading shots and five on the trailing, there are twenty-five possibilities.)

To make slight adjustments in the cutting-points, special adjustment thumbwheels or other custom controls can be provided. The ~~trim lap~~ pair would then be seen again.

¶ Complete control of a trim is available from a diagram which we may call the "trimming map." This shows the different possible cutting-points, tells their distances apart in frames or seconds, and displays comments the editor may have typed in about the alternative cuts.



This is a map showing six different cutting-points, and four alternative possible "splices" between them. The editor has written comments on two of them.

He may ask to see ~~look at~~ the four alternatives in quick succession.

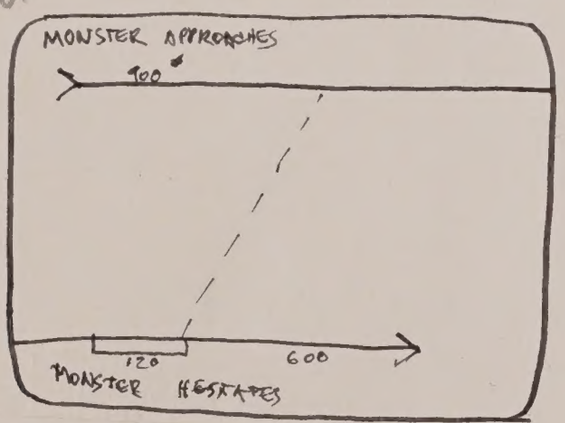
Trim

¶ The trimming map is not merely ~~a~~ to show the editor the situation; it is a control device as well. The editor may point at a line indicating the cut he wants to see, and see it immediately. Or he may point at a cutting-point and slide it on the line representing the shot. The lines representing cuts will adjust accordingly, and the numbers showing the distances among cutting-points will change continually to keep up.

¶ ~~I should point out that~~ To make such an adjustment on the ~~lap~~ trimming map should take no more than ten seconds.

After operating upon the map the editor may obtain an immediate replay that shows the new change.

¶ Replay techniques can help the editor make choices within a trim range. Suppose the editor has picked out a trim range for a cut:



The two shots can be shown superimposed for the duration of the ~~lap~~ trim range, or simultaneously on two monitors, or a dissolve can take place on a single monitor, beginning at the start of the ~~lap~~ trim range and ending at the end of the ~~lap~~ trim range. The editor may make a quick adjustment on the ~~lap~~ trimming map, and immediately see the resulting cut.

¶ Shots assembled according to an assembly list
will be stored in alternation on two VTRs, making trim variations easy.

¶ In case the reader doubts the
speed with which trim pairs can be replayed, consider the following:
~~beside~~ ~~the one that holds~~ technique for getting them ready. Suppose there are four VTRs
~~beside that holds~~ The original footage. If we copy the first shot simultaneously
onto all four, and then copy the second shot simultaneously onto all four,
it will be possible for the computer to ~~keep~~ juggle the machines so as to
show the first shot from one VTR, and then the second from another VTR,
the machines not playing at a given moment would be backing up.
By alternating VTRs, the computer ~~could~~ can cut from one to the other
at any pair of cutting-points.

para

¶ Let us sum up the information facilities available on the system.

¶ In preliminary viewings of the material, the editor ~~would have~~ has the option of logging in the following information, to whatever degree of detail he likes:

shot descriptions, titles and comments (with varying abbreviations)
original shot endpoints and frame-time of events
script correspondences of all shots,
and frame-times of script events
as needed
cutting-points under consideration
categorizations.

NO ¶ Lists, playbacks and correspondence maps of all those materials ~~would be~~ are available in whatever degree of detail they have been logged into the system. However, further detail may be added to any of this information at any time, so that it does not have to be done intricately at the beginning.

¶ It will also be possible for the editor ~~to request out-takes,~~ to see, on request (and without assembly lists), categories of shots, out-takes, ~~and shot-ends~~ or shot-ends that have been cut. ~~leftovers and other collections of shots without assembly lists.~~

frames ¶ The editor ~~could~~ may also enquire at any time as to the length of assemblies he has specified, in time, frames and number of shots. He may also find out the length of categories and leftovers.

NO ¶ He may also ask the system how many combinations are possible with selected sets of shots or cutting-points and ~~how many shots there~~ subject to certain other exact conditions he may specify. ~~Possible combinations~~

~~¶ It will be possible for the editor to inquire of the system~~

No ¶ He may also ask whether he has repeated any shots, or parts of shots, in a given assembly, or whether he has changed the original sequence among some set of shots. ~~in any way.~~

[new page] HOOKUP

A number of technical conditions must be satisfied in order to connect the computer to VTRs and switching equipment.

The operations of the VTRs must be placed under electronic/solenoid control, and appropriate electrical connections made to the computer through a custom interface. While the conventional operations would be adequate — play, record, reverse and fast forward — several other operations would be very helpful. These are stop frame, "go forward one frame" and "go back one frame," which would be helpful to the editor, and one operation which would be quite helpful to the computer — "transfer in reverse," i.e., record from one VTR going backward to another VTR going backward.

electronic/solenoid

Signals from VTRs back to the computer are also necessary. The central synch pulse for all VTRs must be counted by the computer; synch in addition, it must be able to count frame pulses from VTRs which are going fast, in either direction. The computer must also be able to monitor each electrical signal indicating the state of each recorder.

frame

No ¶ The edited marking track should have its normal function disabled, and either by digital means, if feasible, have full address information put on it for each frame, or have a mark stored every 4096 frames on the tape (assuming a 12-bit computer).

sleep

¶ ~~*~~ Appropriate ~~**~~ video and audio switching systems must be placed under computer control. ~~It~~ ~~that~~ ~~the~~ Switching ~~***~~ complexes meeting this criterion ~~are available from~~ are available, as catalog items (from Whistler and ~~Trumpeter~~ Trumpeter), but some design work is needed to accommodate all system elements. These include monitors, amplifiers as needed, and audio and video attenuators, also under computer control, for sound mix and video fades.

¶ None of these requirements presents any intrinsic difficulty. Skilled firms are available to build the computer interface (in particular, Ann Arbor Computer Co. for computers by Digital Equipment Corp.). The video switching network is a fairly normal transmission problem. VTR modification for control and ~~feeding~~ feedback requires tapping existing circuits and converting signals. And finally, creating additional VTR operations is a feasibility and cost-effectiveness problem.

[new page] INFORMATION STORAGE AND INTERNAL OPERATIONS

The whole system is based on keeping complicated lists up to date: ~~keeping complicated, up to date lists~~ lists of the original shots and their original locations

(or "addresses"), lists of ~~their~~ The shots' categories and correspondence to the script, assembly lists, up-to-date lists of cutting-points, and lists of the other locations at which shots are presently available. ~~have been transferred.~~ ~~lists of~~

¶ Recent developments in information processing — called, appropriately, "list processing" and "pointer" techniques — now make it possible to handle all of these lists ~~lists~~ effectively, regardless of their interconnections and changes made in them.

No ¶ These lists are maintained on the computer's disk memory and tapes, ~~and~~ parts of them are called into the computer's fast core memory, as needed, to be revised, displayed on the screen, or examined as a basis for computer action. Chief among these is the ~~basic~~ original shot-number list, to which all the other lists refer, including the lists of ~~the cutting-points~~ derivative shots and cutting-points.

¶ The basic operations of the ~~computer~~ system are concerned with the transferring and sorting of shots among VTRs. A transfer is made by positioning each of two VTRs at an exact location, ~~and~~ interconnecting the output of the first to the input of the ~~three~~ second, sending the first an instruction to play, and sending the second an instruction to record, a few millionths of a second later. The computer counts frames until the required number have passed, then stops both VTRs.

¶ The basic function of the system, - assembling video recordings, is carried out as a cascade of such transfer operations, with as many transfers as possible occurring simultaneously. ~~The limitation is not~~ (VTRs will frequently have to wait for one another, as it takes two to transfer.)

v. rewrite

¶ The details of programming shot-transfer operations are intricate but orderly. ~~Each function operation Smaller operations~~

Smaller operations are combined into larger ones, and these larger ones in turn combined into still larger ones.

Consider this list of computer-controlled operations, beginning with the smallest.

¶ To get to an address on tape, the computer subtracts the present position of the VTR from the desired address, then goes forward or back the resulting number of frames.

¶ To transfer a shot, the computer must position both the originating VTR and the receiving VTR at the correct address, then start them simultaneously playing and recording.

¶ To transfer a whole assortment of shots, all the individual shots in the group must be transferred separately according to a layout plan.

¶ To plan the layout for a multiple overall transfer, the computer must work out details of the desired optimum sequencing on each VTR, proceeding from an intermediate or "get-together" list, which This list is either supplied by the editor or derived automatically from the script list.

EQUIPMENT AND COSTS

¶ Many different computers could do the job.

¶ Of currently available machines, probably the most suitable, is the Digital Equipment Corporation Linc-8, for several reasons.

A small computer with a 12-bit word length, the Linc-8 is the only computer presently sold with a built-in general-purpose CRT display. Various other "extras," essential for this system, are also built-in: alphabetical character generator for the CRT, a fast tape memory, analog-to-digital converters (for throttles and mouse), and external outputs and relays for the connection of miscellaneous equipment. The machine is especially suited to flexible experimentation.

¶ This system is both comparatively inexpensive ($38,000 basic, est. $65,000 with all necessary extras) and comes as a standard unit from a single and reliable supplier. This reduces initial problems of procurement and installation.

The next more expensive computer would, with all the extras, cost between $120,000 and $150,000. While such a system would be somewhat easier to program — and would probably be the right system for service, several users at the same time — the problems of hookup, mixed vendors and tied-up capital would argue for beginning with the smaller system.

¶ The use of this equipment would also permit expansion by evolutionary stages to larger systems, capable of controlling remotely a dozen editing studios at once, at a much lower cost per studio controlled.

¶ This equipment would be capable of the text displays described here, but no more. (The Linc-8 can display at most about ~~400~~ 500 letters at once, allowing for ~~some phosphor persistence when added by the TV link.~~ use of a long-persistence use of a variable-persistence oscilloscope, such as the Hewlett-Packard 141 A.)

If more extensive text display is desired, or more detailed diagrams, ~~this requires~~ additional outlay would be required. Either a scan conversion/storage system could be added (costing about $20,000) or, for text in motion, the "330" display system ($45,000 when added to the Linc-8). The 330

~~($45,000 when added to the Linc-8).~~ ~~This~~ The 338 would be the natural ~~next~~ step in expansion; the final expansion would keep the 338 display but mount it on a bigger computer (presumably the PDP-9). This system would present a richer CRT display ~~set~~ and be able to service several users at once, whether nearby or in a distant studio.

¶ Naturally, all these equipment choices ~~are not~~ are based on the current market. ~~As prices fall~~ As new machines appear, and computer prices continue to go down, — perhaps as much as 50% by 1973 — ~~other~~ other machines may ~~turn out~~ suggest better avenues of expansion. ~~In principle, however, this configuration will not become obsolete.~~

~~Five years from now the computer prices should be one-half to one-quarter of these figures.~~ ¶But the competitive advantage of beginning now should be obvious, and the configuration described here will not become obsolete.

¶ The cost of programming, overhead and maintenance is in the same range as the cost of the computer: $65,000 to $150,000.

¶ The cost of the switching system, including digital interface, cannot be estimated here. For the sake of an overall figure, let us assign it a cost between $30,000 and $50,000.

¶ VTR modifications and interface costs could probably be held to $5000 per recorder, perhaps less.

¶ Construction of a functioning system will take one to two years, including delivery time on the computer (six months or more). A third year should be allowed as a cushion, since unexpected difficulties are not unknown in the computer field.

COST ESTIMATES

	Low	High
Computer & display	65	150
Programming, maintenance, overhead	65	150
(Switching system	30	50)
(VTR modifications, 8 units	40	40)
three-year total	200	390

¶ The whole system, then, should cost between $200,000 and $390,000. (This figure does not include the cost of possible patents.) Starting now, it should be finished, as described, by late 1970.

¶ These figures assume a conventional project undertaken from the outset as a complete package. There are, however, possible arrangements that would limit financial commitment by stages. In particular, ~~postponement~~ postponing the videotape interfaces until key aspects of the services are programmed would provide assurance of feasibility without very much overall delay.

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